Nutrient cycling in rainfall, throughfall and stemflow in Brazilian semiarid region: dry year x rainy year

Karinne RD Leal[1], Maria C Forti[2], Laura deS Borma[2], Roberta LM Alcaide[2], Francis HT Firmino[3], Apolo A Ribeiro[3], Sebastião TD Leal[4]

[1] Doctoral student in Earth System Science, Brazilian Institute for Space Research – CCST/INPE karinne.leal@inpe.br; [2] CCST/INPE; [3] UFRPE ; [4] Petróleo Brasileiro SA - PETROBRÁS

Objective: assess rainwater, throughfall and stemflow chemical composition, among years with different rainfall rates in Brazilian semiarid.

Introduction

Rainfall brings nutrient from atmosphere to the ground scavenging them from the atmosphere column. Furthermore, throughfall washout material deposited on plant tissues as well as leachates exudate products resulting in changes in the rainwater chemistry. Inputs of nutrients into the soil through such processes are important for nutrient recycling and it depends intimately on the hydrological characteristics of the environment. These relationships are poorly understood for environments with low water availability and high temporal and spatial variability like the arid and semiarid ones. For instance, in some years, rainfall events are regular but in some years, it can delay or even not occur. The knowledge of the consequences of these hydroclimatic pattern on nutrient cycling is still rare[1].

This poster is part of the thesis of first author. Here are shown preliminary results concerning the hydrological fluxes as well as chemical composition of rainwater, throughfall and stemflow in a typical vegetation cover in the Brazilian semiarid.

Study area

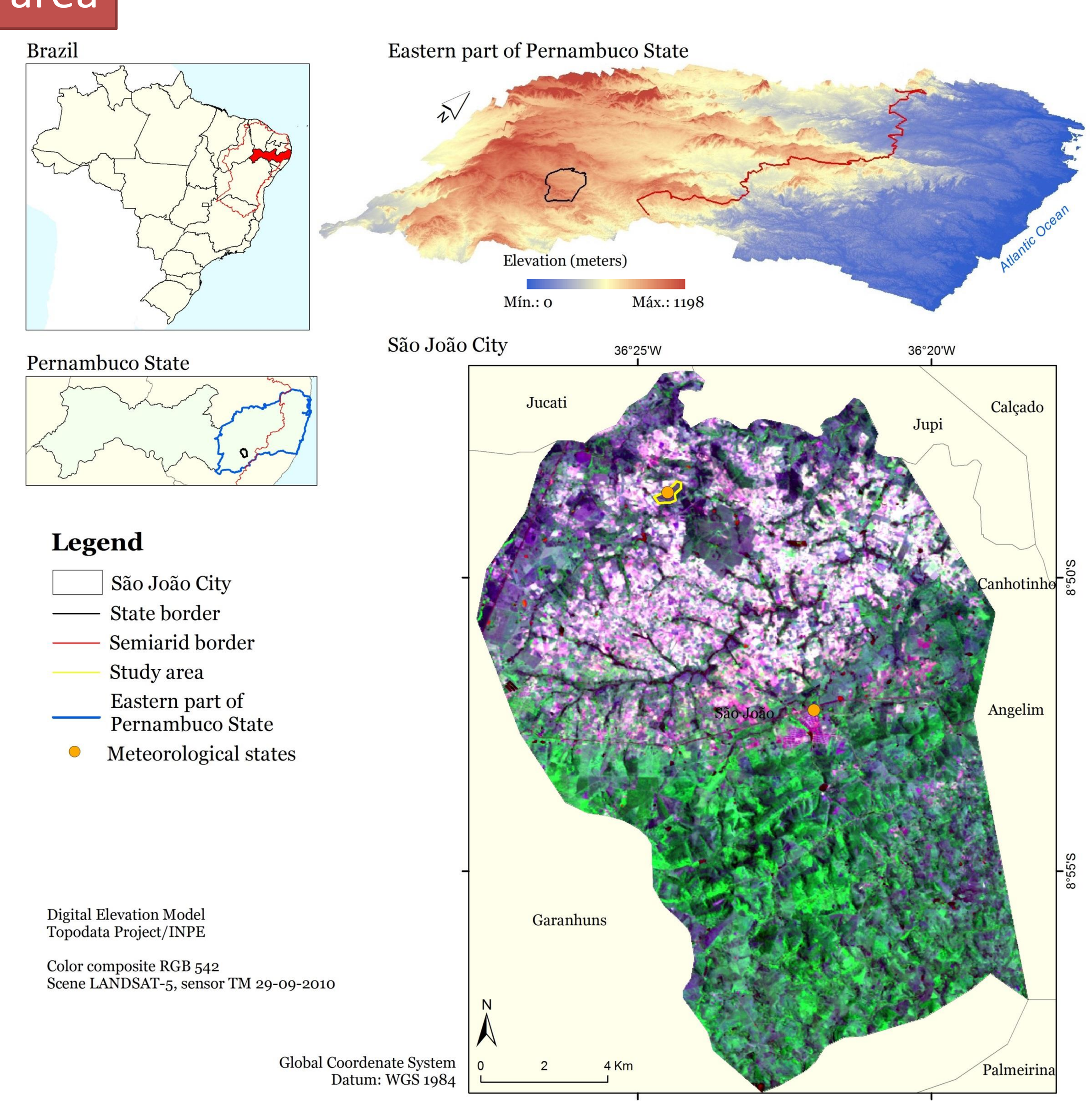

Figure 1: location of the study area.

São João - PE

- Brazilian semiarid
- Caatinga biome (10% of Brazilian territory)
- Straight distance to the coast: 135 km
- Historic annual rainfall: 780 mm
- Irregular rainfall in space and time
- Regosols (weakly developed)
- Caatinga vegetation is 60 years old and is mainly used for fuel wood consumption

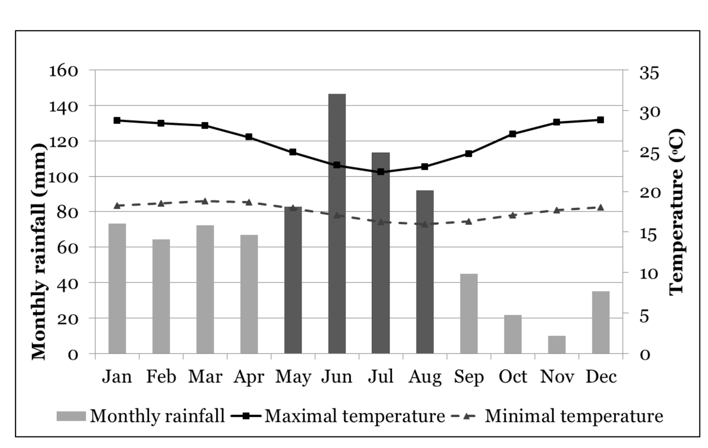

Figure 2: Decennial (1999-2011) mean rainfall, maximal and minimal temperatures for São João, in Pernambuco state. Highlight to rainy season.
Source: Pernambuco State Agency of water and Climate - *APAC* .

Method

Rainfall, throughfall and stemflow were collected in order to determine hydrological fluxes and characterize its chemical composition.

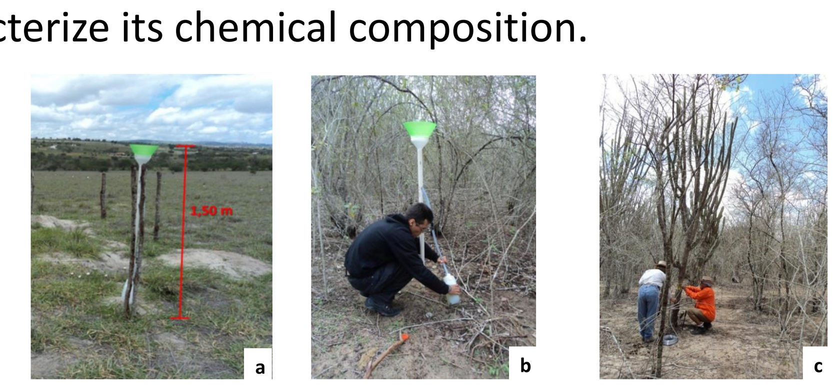

Figure 3: Water field sampling using manually produced plastic funnels . A) rainfall, B) throughfall and c) Stemflow

Two field campaigns: 2012 and 2013 - April to August. Samples were collected in triplicate, once a week totalizing 30 set of samples.

Samples were analyzed for soluble inorganic ions (Cl^-, NO_3^-, SO_4^{2-}, Na^+, NH4+, K^+, Ca^{2+}, Mg^{2+}) using ion chromatography.

In order to determine non-sea-salt (nss) concentrations of a given species, Cl^- was used as the reference for marine origin using the following equation[2]:

$$\text{NSS } x = \lfloor x_a \rfloor - \left(\lfloor Cl^-_a \rfloor \times \left(\frac{x}{Cl^-}\right)_s\right)$$

Where:

$\lfloor x_a \rfloor$ and $\lfloor Cl^-_a \rfloor$ = concentration of the specie in the samples

$\left(\frac{x}{Cl^-}\right)_S$ = ratio in seawater

References

[1] Austin, a. T.; Yahdjian, l.; Stark, j. M.; Belnap, j.; Porporato, a.; Norton, u.; Ravetta, d. A.; Schaeffer, s. M. Water pulses and biogeochemical cycles in arid and semiarid ecosystems. **Oecologia**, v. 141, p. 221-235, 2004.
[2] Berner, EK and Berner, RA. (1987) **The global water cycles: Geochemistry and Environment**. Prentice Hall, New Jersey.
[3] LI, X-Y. Hydrology and biogeochemistry of semiarid and arid regions. In: Levia, D. F.; Carlyle-moses, D.; Tanaka, T. (eds). **Forest Hydrology and Biogeochemistry**. Netherlands, p. 285-299, 2011.

Results

Precipitation was 58% and 30% lower than historical average in 2012 and 2013, respectively. However, local site measurement reported a lower rainfall for both years. This spatial and annual rainfall variation is characteristic of semiarid environments. Of the total rainfall, 67% and 73,7% reached the soil as throughfall in each year. In semiarid vegetation the mean throughfall is about 49%[3], with a variation coefficient of ±32%. Caatinga hydrological fluxes estimated in this study is similar to those reported in the literature. Stemflow was measured in 2013 only and represented 1.2% of the total rainfall.

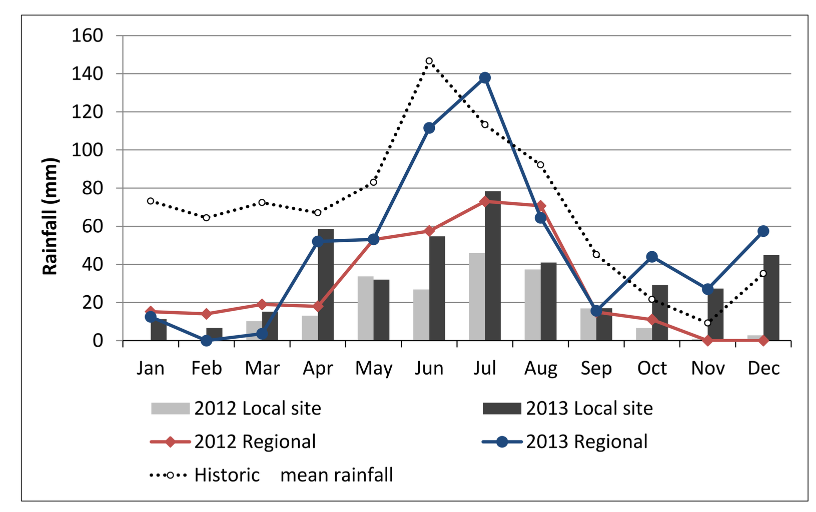

Figure 4: Rainfall in São João-PE, measured in local site in 2012 and 2013 (columns) and regionally measured by APAC (lines). Dotted line show historic rainfall.

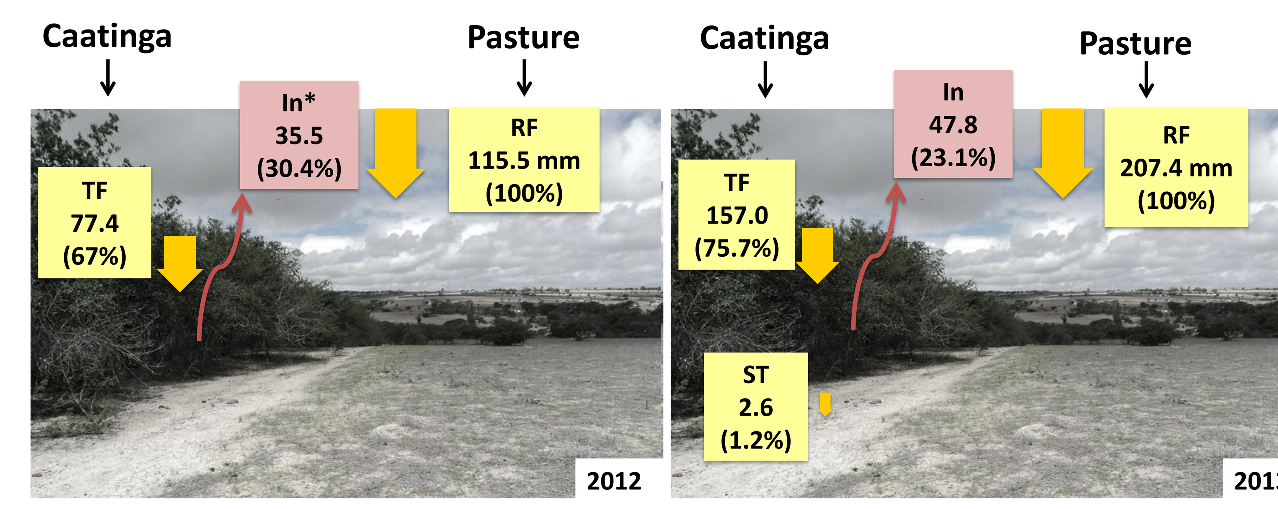

Figure 5: Measured hydrological fluxes in a natural vegetation (Caatinga) and in a pasture. RF: rainfall; In: interception; TF: throughfall, ST: stemflow. Figures are in mm.rainy season^{-1} and in percentage.
*Taking into account the same percentage of stemflow measured in 2013.

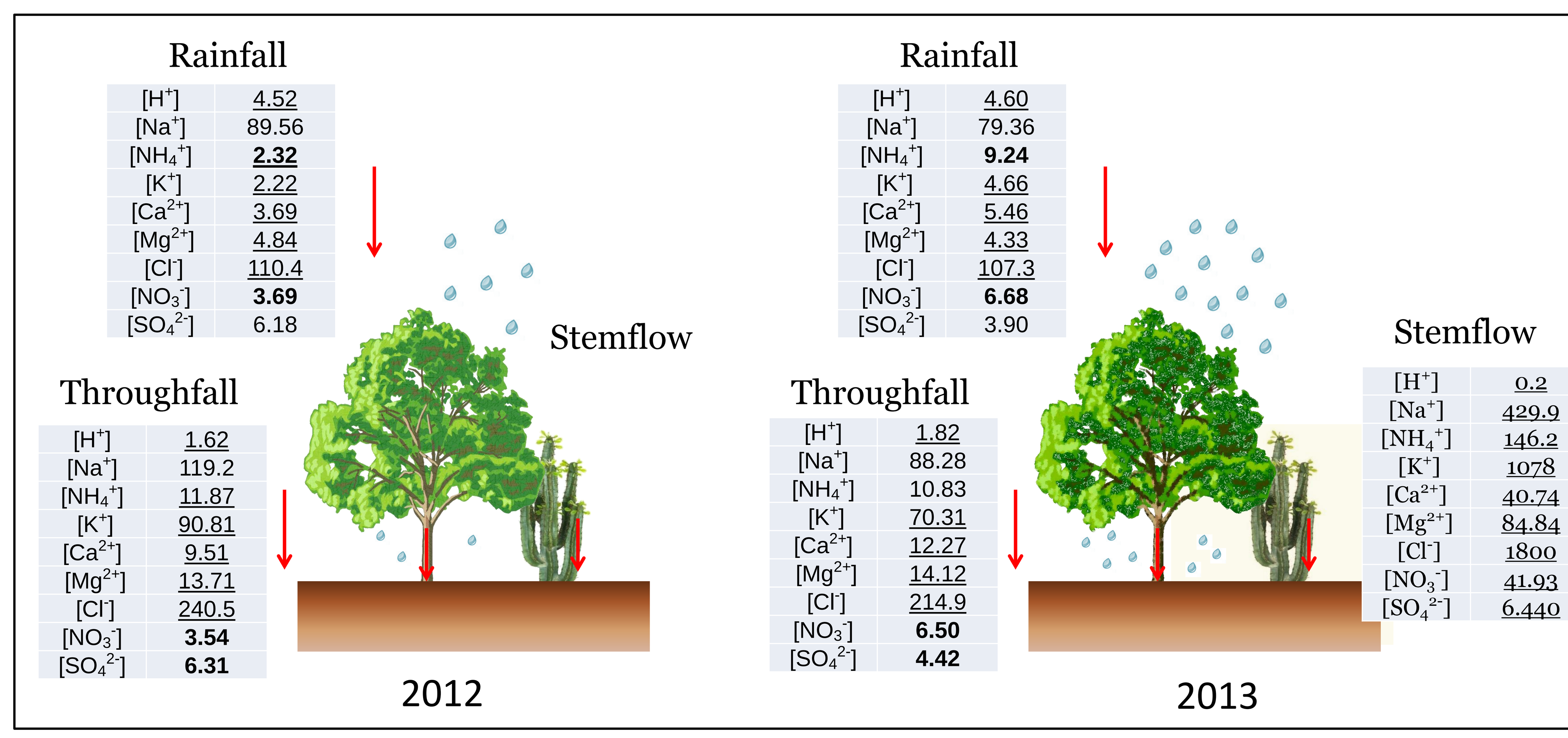

Figure 6: Concentrations (µEq.L^{-1}) for Rainfall, throughfall and stemflow in eastern portion of Brazilian semiarid in 2012 and 2013. Stemflow was not measured in 2012. Figures in bold shows significant statistical difference between years (same hydrological component) and underline figures shows difference between hydrological components (same year). Kruskal-Wallis nonparametric test at 5% significance level.

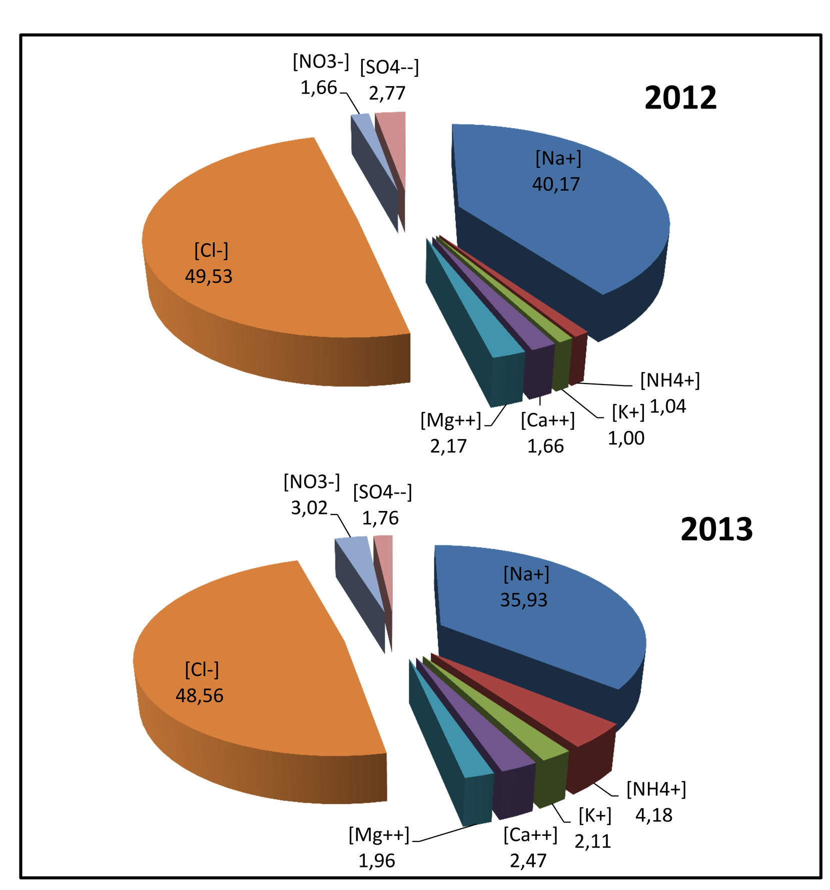

Figure 7: Percentage (µEq.L^{-1})of main ion concentrations of rainwater.

Table 1: Rations for ions in rainwater for both years and comparison with seawater.

Ion	Seawater	Rainwater 2012	Rainwater 2013
Cl^-	1.00	1.000	1.000
Na^+	0.858	0.811	0.740
SO_4^{2-}	0.052	**0.112**	**0.073**
Mg^{2+}	0.097	0.088	0.081
Ca^{2+}	0.019	**0.067**	**0.102**
K^+	0.019	0.020	**0.043**

Table 2: Non-Sea-Salt concentrations (µEq.L^{-1}) in rainwater for both years.

	Rainwater 2012	Rainwater 2013
Na^+	-5.20	-12.67
SO_4^{2-}	**6.61**	**2.22**
Mg^{2+}	-1.02	-1.75
Ca^{2+}	**5.30**	**8.87**
K^+	**0.12**	**2.62**

General Coments

Hydrological flows showed no statistically significant difference between years despite a better development of the vegetation in the second year.

Differences in NH_4^+ and NO_3^- concentrations between years can be assigned to chemical fertilizers use in the pasture area in 2013.

Chemical composition of rainwater, throughfall and stemflow points out to a enrichment nutrients as the water passes through the canopy, highlighting the influence of the dry deposition and leaching of exudates in this semiarid ecosystem.

The dominant species for rainwater were marine (Na^+ e Cl^-), representing 90% and 85% of the total content in 2012 and 2013, respectively. Rainwater rations were similar to those in seawater, suggesting a marine origin for that ions. NSS fraction was dominated by SO_4^{2-} and Ca^{2+}.

Acknowledgement

We are thankful to FAPESP; Postgraduate program in Earth System Science - CST/INPE; Prof. Dr. José Romualdo de Sousa Lima, Prof. Dr. Gustavo Pereira Duda and graduating student Alleph Miquéias Pereira de Almeida - Federal Rural University of Pernambuco state – UFRPE; Laboratory of Aerosol, Aqueous Solutions and Technologies - LAQUATEC / INPE and fellows Roberta Lee Macivieiro Alcaide, Stéphane Palma Crispim, Mariana de Almeida Souza, Noélli Lemes Garcia and Kelly Ribeiro; Dr. Eráclito Sousa Neto and MSc. Grasiela Rodrigues - CCST/INPE.